ONR Program Evaluates Emerging Energy Technologies at Naval Facilities

Energy Systems Technology and Evaluation Program Seeks to Increase Energy Security

THE OFFICE OF Naval Research (ONR) has launched an ambitious program to demonstrate and evaluate energy technologies using Navy and Marine Corps facilities as test beds, known as the Energy Systems Technology and Evaluation Program (ESTEP).

ESTEP focuses on energy technologies that reduce costs, increase energy security, and ultimately increase the reach and persistence of the warfighter. The entire program encompasses the following investment areas:

- Cyber and Energy Management for Information Systems
- Power and Energy Components
- Power and Energy Production/Efficiency

ESTEP, established in fiscal year 2013, is casting a wide net across the Department of the Navy, academia, and private industry to investigate and test emerging energy technologies at Navy and Marine Corps installations. At present, ESTEP conducts over 20 in-house government energy projects, ranging from energy management to alternative energy and storage technologies. Additionally, an ESTEP Broad Agency Announcement has awarded several contracts to industry in those same energy areas.

In addition to testing and evaluating performance and reliability of energy technologies, ESTEP provides mentoring (via on-the-job training and education of interns) and other workforce development opportunities by partnering with the Troops-to-Engineers program for veterans at San Diego State University and other universities. "Workforce and professional development are key components of ESTEP and integral to the success of executing and transitioning energy technology projects at naval facilities," said Dr. Richard Carlin, director of the Sea Warfare and Weapons Department at ONR as he highlighted the essential elements of the program.

ONR provides funding and oversight for ESTEP, and program management is being handled by the Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific (SSC Pacific). The Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) and the Naval Postgraduate School (NPS) are executing selected research projects, and every project plans to involve at

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>
> *–Dr. Richard Carlin*

least one intern utilizing the ESTEP grant under the Troops-to-Engineers program. Students at NPS will also assess the business side of energy technologies, analyzing the costs, savings and return on investment of different efforts.

Speaking about this unique partnership, Rear Admiral Patrick Brady, SPAWAR commander, said, "The Navy benefits from the internship of highly motivated and talented individuals supporting our Navy's energy and energy management research projects. Likewise, our returning veterans gain valuable experience working in their future career field while they pursue their engineering degrees."

The purpose of the ESTEP effort is to identify viable emerging energy technologies, obtained for the most part from open-market sources and in-house government demonstrations. Technologies identified as promising by ESTEP will be demonstrated, and data will be collected to evaluate the performance and reliability of selected technologies under various environmental and operating conditions.

The Asia-Pacific Technology and Education Program

A program with similar goals in the Pacific region is the Asia-Pacific Technology and Education Partnership (APTEP), centered in Hawaii. This program was formed as a response to Hawaii's historically high energy rates and dependence on fossil fuel, and facilitated by plentiful sun and wind resources and by the local government's motivation to explore alternative energy. Though centered in Hawaii, this ONR-sponsored program has the ultimate goal of facilitating energy technologies that will benefit naval facilities and the nation.

APTEP takes a three-pronged approach:

1. Supporting cutting-edge energy research.
2. Educating students and teachers in energy-related fields.
3. Providing seed money to companies with promising technologies in the renewable energy field through its Energy Excelerator program.

Dr. Carlin is looking for ways to connect ESTEP with APTEP, such as linking SPAWAR with the University of Hawaii/West Oahu to include student veteran participation. The office is also exploring opportunities for Energy Excelerator company products to be used in ESTEP projects.

For more insights into APTEP visit www.aptep.net.

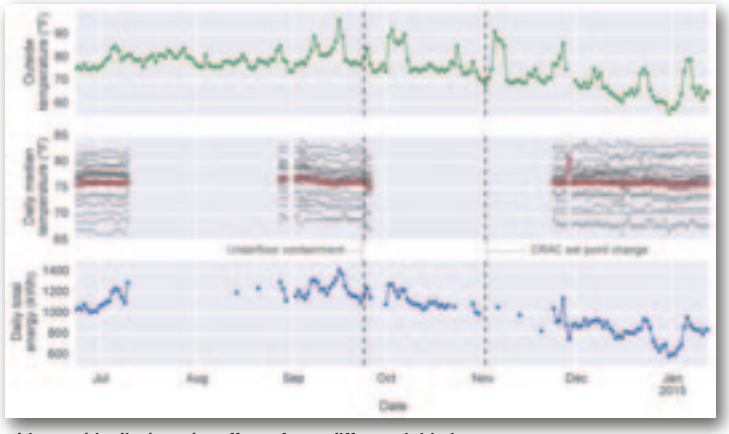
ESTEP Projects

Here is a snapshot of ESTEP projects past and present.

Data Center Smart Metering

Because data centers consume large and growing amounts of electricity, this project is aimed at reducing energy use through the use of smart metering.

Principal Investigator: Daniel Grady, Ph.D., SSC Pacific, daniel.grady@navy.mil, 619-553-2793



This graphic displays the effect of two different initiatives, underfloor cold-air containment and climate control set point adjustments, on the daily total energy used by the data center's chiller plant (bottom), ensuring that the required temperature inside the Information Technology room was maintained (red line), and correcting for external air temperature. Underfloor containment did not improve the efficiency of the system, but adjusting set points resulted in approximately $6,000 per year in energy savings.

Cyber Supervisory Control and Data Acquisition (SCADA) Capability Evaluation

This program, of special interest in the developing energy management industry, tests for vulnerabilities in a SCADA network.

Principal Investigator: Jose Romero-Mariona, Ph.D., SSC Pacific, jose.romeromariona@navy.mil, 619-553-8119

Cyber-SCADA Evaluation Capability (C-SEC) on the Move

C-SEC on the Move will leverage the C-SEC framework and tools in order to provide a mobile user experience, allow for a more diverse repository of evaluations and further integrate security and return on investment estimations.

Principal Investigator: Jose Romero-Mariona, Ph.D., SSC Pacific, jose.romeromariona@navy.mil, 619-553-8119

Virtual Smart Grids for Net Zero Capability

This program is demonstrating a virtual smart grid to manage and achieve net-zero energy goals at the regional scale.

Principal Investigator: Eric Evans, SSC Pacific, eric.evans@navy.mil, 619-553-1597

Seamless Integration of Geographic Information Systems (GIS) and Electrical Architecture Models for Smart Grids and Net-Zero Energy Goals

Using commercially available software for electrical engineering and the model built under the ESTEP Virtual Smart Grid project, this project team will integrate the model into the Navy's GIS program.

Principal Investigator: Eric Evans, SSC Pacific, eric.evans@navy.mil, 619-553-1597

Optimization Tool for Hybrid Energy Systems

This project is evaluating storage solutions for renewable energy by analyzing energy data and developing an optimization energy management strategy. The specific area being investigated involves hydrogen generation and storage.

Principal Investigators: Andrew Higier, Ph.D., SSC Pacific, andrew.higier@navy.mil, 619-553-2769

Jonathon Oiler, Ph.D., SSC Pacific, jonathon.oiler@navy.mil, 619-553-5844

Energy Efficient Cloud Computing Evaluation and Demonstration

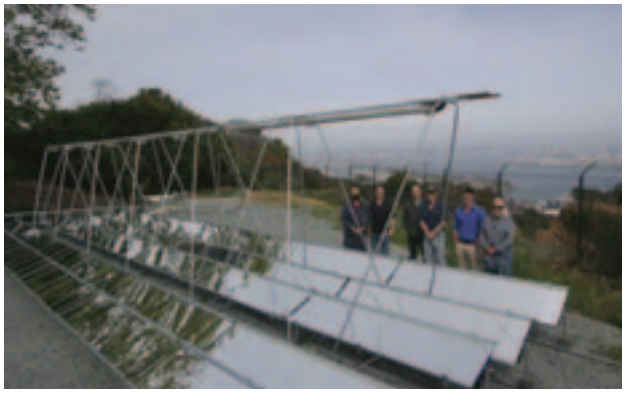
The goal of this project is to improve the energy efficiency of the Navy's cloud computing architecture.

Principal Investigator: Chris Chen, SSC Pacific, chris.chen@navy.mil, 619-553-6852

Deep Subgrid-parity Solar

This project is aiming to dramatically lower the cost of photovoltaic (PV) panels by fabricating and installing a prototype design that is lighter weight, easier to install and more efficient than current technology.

Principal Investigator: Randall Olsen, Ph.D., SSC Pacific, randall.olsen@navy.mil, 619-553-8713



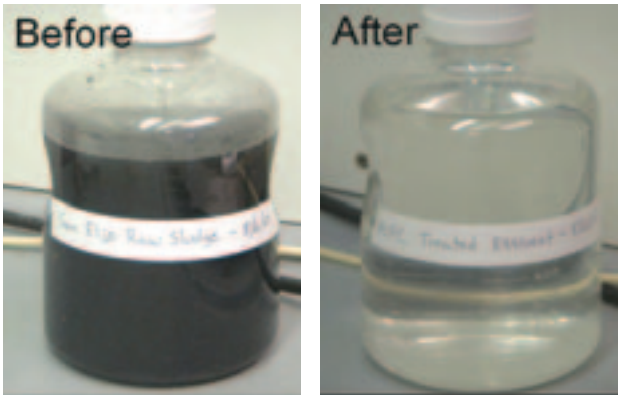
The Deep Subgrid-parity Solar project team with a prototype design.

Energy and Water Recovery by Microbial Fuel Cells

This team is exploring the possibility of utilizing microbial fuel cells to treat wastewater. (A microbial fuel cell is a bio-electrochemical system that drives a current by mimicking bacterial interactions found in nature.)

Principal Investigator: Lewis Hsu, Ph.D., SSC Pacific, lewis.hsu1@navy.mil, 619-553-4934

Pilot scale (100-gallon) microbial fuel cell reactor system operating in spill containment bins.
Orianna Bretschger



Samples of raw wastewater (left) and treated, clean effluent (right).
Orianna Bretschger

Microbial fuel cell reactor system before placement into secondary containment bins.
Orianna Bretschger

Radio Frequency Identification (RFID) Reading Outlets for Device Level Granularity in Building Energy Control

This project will install RFID tags on device plugs, conserving energy by enabling power to be turned on or off remotely.

Principal Investigator: Wayne Liu, SSC Pacific, wayne.liu@navy.mil, 619-553-1900

Marine Corps Base Hawaii Energy Management Evaluation Seed (Completed)

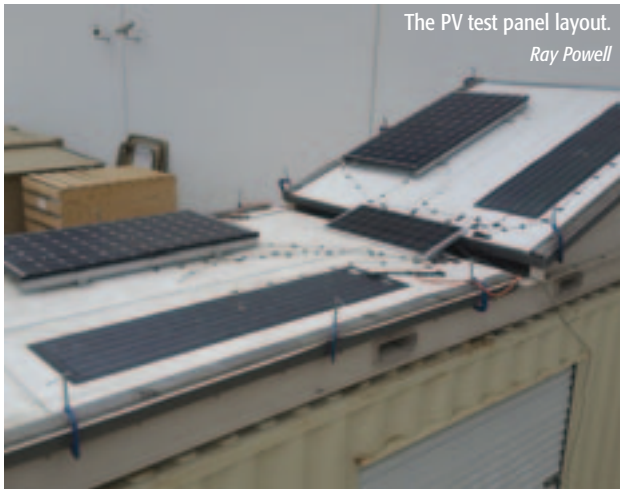
This project team supported the installation of a Smart Meter energy management system at Marine Corps Base Hawaii.

Principal Investigator: Tyler Chun, SSC Pacific, tyler.chun@navy.mil, 808-471-3494

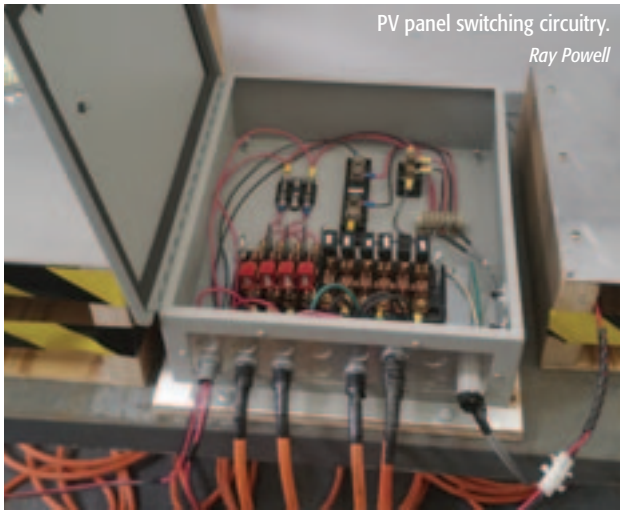
Adhered PV Reliability and Performance

The goal of this project is to compare adhered PV to traditional frame-mounted PV systems. Testing procedures will determine if adhered PV subjects the roof materials to excessively hot temperatures or affects interior air temperature. Also studied will be ease of installation, adhesion properties, and removal of malfunctioning panels.

Principal Investigator: Robert Schoff, NAVFAC EXWC, robert.schoff@navy.mil, 805-982-3572



The PV test panel layout.
Ray Powell



PV panel switching circuitry.
Ray Powell

Advance Power Electronics for PV Inverters

PV inverters convert the direct current power generated by PV systems into alternating current power that can be connected to the grid. This project will evaluate a new, more efficient PV inverter.

Principal Investigator: Ken Ho, Ph.D., NAVFAC EXWC, ken.ho@navy.mil, 805-982-1636

The Ideal Power PV converter (right) at Port Hueneme takes the place of six older converters.
Ken Ho

This electric vehicle (EV) charger has two Ideal Power converters on each side, enabling the EV charger to be bi-directional.
Ken Ho

Light Detection and Ranging (LIDAR) Wind Experiments and Validate Simulated Integration of Renewable Energy Networks (SIREN) Computer Modeling

This project is mapping shifts in wind quality over varying terrain for wind energy development applications. Additionally, the team will produce a SIREN model to help determine the transient effects of renewable components on a utility electrical system. SIREN software will be validated in field tests.

Principal Investigator: Ben Wilcox, NAVFAC EXWC, benjamin.wilcox@navy.mil, 805-982-2180

The LIDAR has been integrated into a trailer with 30-meter telescoping mast to create a trailer-based meteorological station.

The LIDAR remote sensor makes wind measurements through a hatch in the trailer roof.

Rooftop Units (RTU) Challenge

This team is researching optimal ways to meet the Department of Energy RTU challenge by identifying energy-saving rooftop heating, ventilation and air conditioning systems.

Principal Investigator: Max Hogan, NAVFAC EXWC, max.hogan@navy.mil, 805-982-1557

Modular Microgrid with Energy Storage

The project will evaluate mobile microgrid controllers and will demonstrate two systems with existing PV arrays at two locations.

Principal Investigator: Robert Okwera, NAVFAC EXWC, robert.okwera@navy.mil, 805-982-5177

DC Micro-grid for Solid State Lighting (SSL)

SSL can reduce building lighting load by up to 80 percent, and direct current SSL eliminates alternating current/direct current drivers resulting in cost savings and increased reliability.

Principal Investigator: Ken Ho, Ph.D., NAVFAC EXWC, ken.ho@navy.mil, 805-982-1636

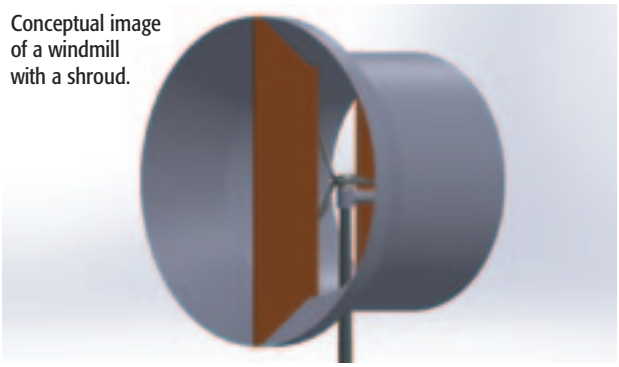
Liquid Air Energy Storage (LAES) with Combined Cycle and Power

LAES provides a low cost bulk energy storage solution using thermodynamic principles. The goal of this project is to validate the technology and prepare for full scale installation.

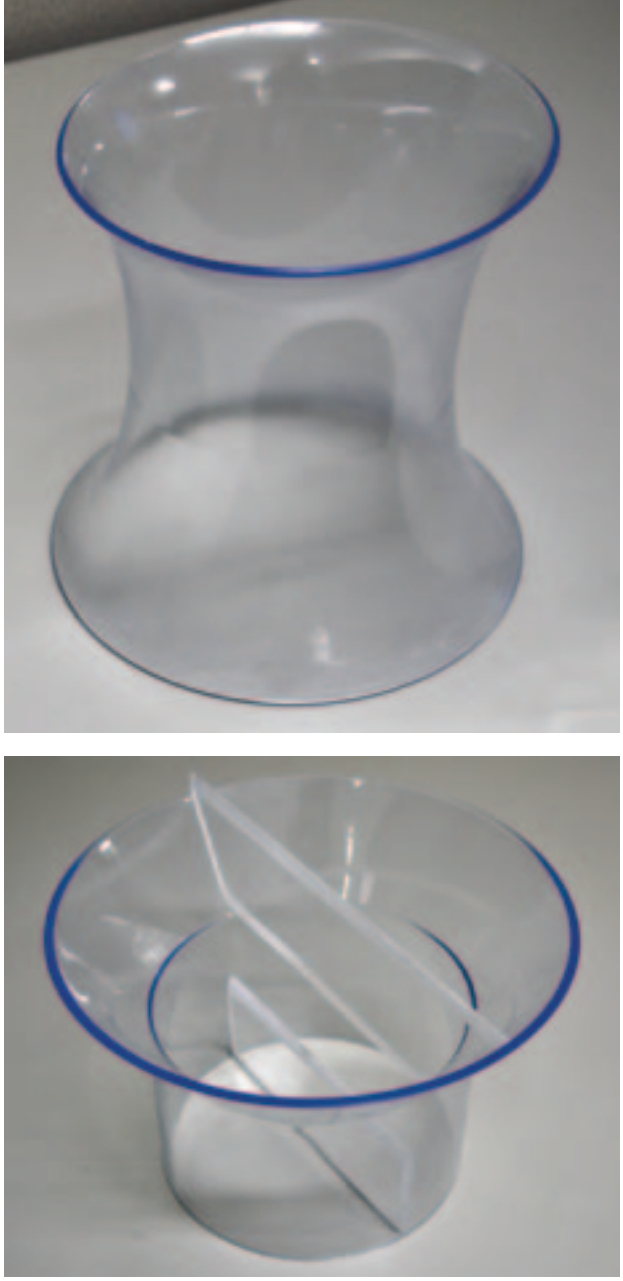
Principal Investigator: Ken Ho, Ph.D., NAVFAC EXWC, ken.ho@navy.mil, 805-982-1636

Shroud with Radio Frequency Mesh to Suppress Radar Cross-section of Small Wind Turbines

This project is developing two shroud concepts to suppress Doppler-filtered radar cross-section of wind turbine rotors, and also facilitate acceleration of air flow.



Conceptual image of a windmill with a shroud.



Two shroud concepts.
David Jenn

Principal Investigators: Ben Wilcox, NAVFAC EXWC, benjamin.p.wilcox@navy.mil, 805-982-2180

David Jenn, Ph.D., NPS, jenn@nps.edu, 831-656-2254

Wind Powered Cooling with Thermal Storage

Naval facilities have cooling loads such as for air-conditioning and data centers and renewable powered chiller systems would reduce the energy costs of these systems. To solve the problem of renewable energy's intermittency, this team used an ice-thermal storage system to generate ice during times of high renewable energy supply and then melt it as a thermal heat sink during times of high heat load.

Principal Investigator: Anthony Gannon, Ph.D., NPS, ajgannon@nps.edu, 831-656-2880

Renewable cooling system.

Commander Rex Boonyobhas peers into the thermal storage unit as Dr. Garth V. Hobson and Dr. Anthony Gannon look on.

Improved Wind Resistant Rooftop PV

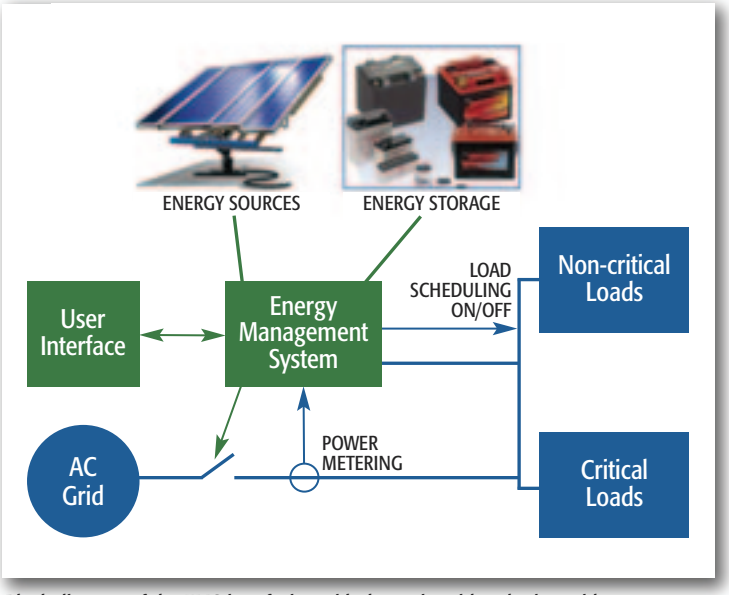
This project is assessing wind loads on a prototype PV unit so that its design can withstand a three-second gust of 150 mile-per-hour wind without the use of adhesives or additional ballasts.

Principal Investigator: M.S. Chandrasekhara, Ph.D., NPS, mchandra@nps.edu, 831-656-3585

Mobile Energy Management System (EMS) Prototype for Field Studies

The goal of this project is to design and build an EMS packaged so that it can be moved to different locations for practical demonstrations and microgrid studies.

Principal Investigator: Giovanna Oriti, NPS, goriti@nps.edu, 831-656-2637



Block diagram of the EMS interfacing with the main grid and microgrid.

Efficient Implementation of Solid State Transformers

For effective implementation of renewable power, a transformer is needed to interface between energy grids on naval bases. This project is studying the advantages of solid state transformers.

Principal Investigators: Todd Weatherford, NPS, trweathe@nps.edu, 831-656-3044

Andrew Parker, Ph.D., NPS, aaparker@nps.edu, 831-656-2483

Optimized Cooling for Concentrated Photovoltaic Systems

The goal of this project is to find optimized cooling solutions for concentrated PV systems that show promise for highest energy efficiency and reliability on Department of Defense (DoD) energy grids and to build a knowledge base across DoD organizations.

Principal Investigator: Sanjeev Sathe, Ph.D., NPS, sbsathe@nps.edu, 408-813-2800

The Navy benefits from the internship of highly motivated and talented individuals supporting our Navy's energy and energy management research projects.

–Rear Admiral Patrick Brady

Heat Recovery from Naval Base Power Plants (for hot water heating)

The goal of this project is to find waste heat recovery solutions that improve heat recovery efficiency and improve reliability without impacting the main system. Solution techniques for analyzing complex recovery systems are being developed.

Principal Investigator: Sanjeev Sathe, Ph.D., NPS, sbsathe@nps.edu, 408-813-2800

Uninterruptible, Renewable, Augmented Power Circuits

This project is demonstrating a practical way to convert individual circuits to uninterruptible power supplies that can use renewable energy and backup power when the grid fails. The participants are using super capacitors instead of batteries for the bridging power which is unique for these types of systems.

Principal Investigator: Anthony Gannon, Ph.D., NPS, ajgannon@nps.edu, 831-656-2880

Cost-Benefit Analysis of Energy Demonstration Projects

The goal of this project is to develop tools through which to evaluate the benefits and costs of ESTEP technology demonstration projects. Potential financial and non-monetized benefits will be considered.

Principal Investigator: Eva Regnier, Ph.D., NPS, eregnier@nps.edu, 831-656-2912

ESTEP fits into the five energy goals announced by Secretary of the Navy Ray Mabus in 2009. Those steps include:

1. Creating a "green" strike group of ships powered by biofuels.
2. Producing at least half of the Department of Navy's shore-based energy requirements from renewable sources.
3. Reducing petroleum use in the Navy's commercial vehicle fleet by 50 percent via hybrid fuel and electric vehicles.

Tony Velasco and Conner Guest (2014 interns) pose in front of vertical-axis wind turbines from an ESTEP project. They studied the potential reduction in utility bills achievable by renewable but intermittent energy paired with storage in a microgrid.

Eva Regnier

4. Weighing lifetime energy costs of new contracts.
5. Ensuring that by 2020, at least half of the Navy's total energy consumption comes from alternative sources.

Understanding more about the performance and reliability of emerging energy technologies will streamline their acquisition and adoption. ⚓

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